THE CREATIVE CIRCLE: SKETCHES ON THE NATURAL HISTORY OF CIRCULARITY

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A HAND RISES OUT of the paper, groping into a larger world. When we believe it is hopelessly beyond the flatness of its origin, it plunges back onto the flat surface, sketching its own emergence from the white sheet. A loop is completed whereby two levels are collapsed, intercrossed, entangled. At this point, what we wanted to hold in separate levels is revealed as inseparable, our sense of direction and foundations seems to falter, and a sense of paradox sets in.

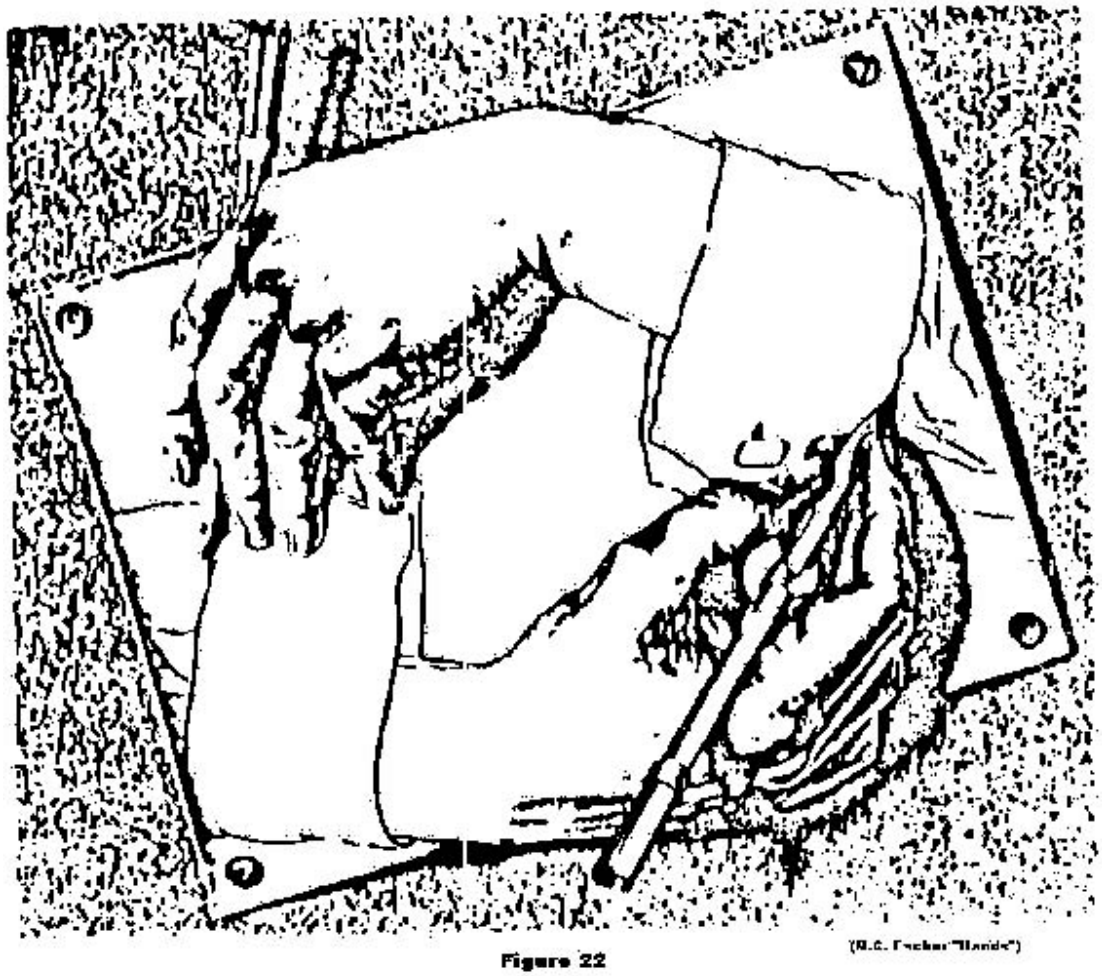


Figure 22

Traditionally such circularities were called vicious circles; they were the epitome of what had to be shunned. But I suggest that they be called virtuous and creative circles. In their

apparent strangeness, there are keys to the understanding of natural systems, their cognitive phenomena, and a rich world of forms. Here I shall offer some sketches of this world of strange loops from three fundamental perspectives: empirical, formal, and epistemological.

THE EMPIRICAL PERSPECTIVE

In the Escher engraving we see that the two hands mutually draw themselves. That is, they mutually specify their conditions of production. They bootstrap themselves out of the engraving to constitute a separate entity. More precisely, their mutual specification sets them apart from the rest of the drawing to constitute a unity. Their operation (mutual drawing) specifies the conditions under which they can be distinguished, setting them apart from a background. To find that a unity sets itself apart from a background by its operations is an ordinary experience we normally associate with living things. Since antiquity, *autonomy* served to designate this experience. If I observe a dog walking on the street and it suddenly changes direction and moves toward me, I generally impute an intention in the dog to greet me. Whether or not such an imputation of mentality is valid is not so interesting to me as the fact that it is tempting to impute intention on the basis of what the dog does. That is, the dog's behavior is difficult to account for unless I observe that the dog confronts its environment not as if it were receiving instructions from this environment for particular outcomes but, rather, as if these instructions were mere disturbances that the dog interprets and constructs according to *its* sense of regulation and balance. This is again that peculiar quality that we call autonomy. In fact, should my car not start one morning, I would be tempted to say it was mad at me; but since I am civilized, I realize that such an imputation is impossible, given that the machine was designed by men in the first place. Perhaps the trouble begins precisely there: We did not design the dog, nor does it seem to be there for any purpose about which we can easily agree. The sharp contrast between living systems that exhibit autonomy and many other natural and man-made artifacts has fascinated biologists since the time of Aristotle and until the nineteenth century, and only the fascination with the diversity of the living could compete in attraction [11]. Interestingly, the theme of autonomy gradually disappeared into the fog of nondiscussion with the rise of genetics and molecular biology by the turn of the century, and, in parallel, the fields of engineering and design developed rapidly, giving rise to cybernetics and control theory. As a consequence, today not only do we not think about autonomy in natural systems, but we simply do not even recognize that such a name could apply to anything that could be made precise. Autonomy's conceptual counterpart, control, can surely be made exact, but not autonomy. There is, of course, no more intrinsic mystery to autonomy than there is to control. The key is to see that autonomy is an expression of a peculiar kind of process that is profusely found in nature in many concrete forms [13]. This kind of *process* is precisely the one portrayed by Escher - parts that mutually specify themselves. It is through this kind of articulation, in the molecular domain, that life specifies itself and acquires its autonomous quality. A cell stands out of a molecular soup by defining and specifying boundaries that set it apart from what it is not. However, this specification of boundaries is done through molecular productions made possible through the boundaries themselves. There is, therefore, a mutual specification of chemical transformation and physical boundaries; the cell draws itself out of a homogeneous background. Should this process of self-production be

interrupted, the cellular components no longer form a unity and gradually diffuse back into a homogeneous molecular soup [8]. The backbone of the cellular organization (Figure 23) can be drawn as follows:

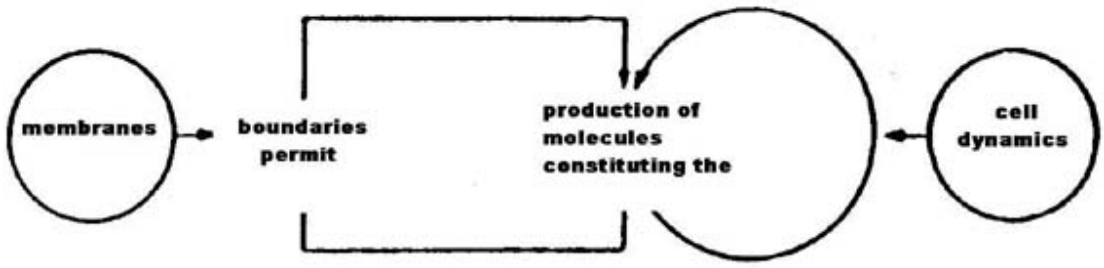


Figure 23

This configuration is the key: *closure* of operations whereby products are in the same levels as productions. In fact, within this organization, the usual distinctions between producer and product, beginning and end, or input and output cease making sense. Little can be said about how cells originated, but a substantial amount of recent evidence is consistent with the idea that the closure just sketched is a necessary condition [3]. Once such autonomous unities are established, a whole new *domain* is generated: life as we know it today. Indeed, on this basic theme of tangled loops of molecular productions, many variations can be played, many different specific configurations, and thus a host of different cells. In fact, it is possible that modern cells arose out of the symbiosis of units that were themselves autonomous and are now only vaguely remembered as mitochondria, chloroplasts, and other organelles [6]. Or even today, algae and fungi mutually satisfy their individual environments for maintenance and form a lichen. Thus cells can interact among themselves so as to constitute themselves new autonomous unities; all multicellular organisms arise under similar circumstances. In such cases, the basic phenomenon is always the same: operational closure of elements in separate levels intercrossed to constitute a unity. When such level crossings and tangledness are interrupted, the unity vanishes. Autonomy arises at this point of intercrossing. The origin of life is no meager example of this general law.

THE STRUCTURAL PERSPECTIVE

"Yields falsehood when apprended to its own quotation" yields falsehood when appended to its own quotation. This Quine [10] koan is a colorful way of presenting a pervasive knot that has been present in the study of language and mathematics for a long time. In fact, ever since the Cretan Epimenides had the odd idea of saying, "All Cretans are liars," the odd quality of self-reference has been a permanent headache [4]. This oddity springs from the assumption that what we say about something should not enter into the constitution of that something. Epimenides-Quine type phrases explicitly violate this assumption. In all such cases of linguistic tangledness, the family resemblance with both the Escher engraving and the emergence of cells and autonomy is apparent. There is the same move whereby that which should have stayed separate (in the Quine or Epimenides

case, levels of meaning) is intercrossed and two levels collapse into one, yet remain distinguishable. What is interesting, however, is that what seemed complex but understandable at the molecular domain acquires a sense of *paradox* in this linguistic domain. It is harder to leap out of the need to stay at a given level of meaning and simply look at the whole sentence as a unity. Paradox is exactly that: that which cannot be understood unless we examine it by leaping beyond both levels tangled in the structure of the paradox. In the Quine or Epimenides case, the phrases remain a paradox unless I am willing to let go of the need to choose between true or false, and see the sentence's circularity as its own way of specifying its meaning. That is, the sentence sits in a larger domain and only becomes paradoxical when projected to the flatter domain of either true or false.

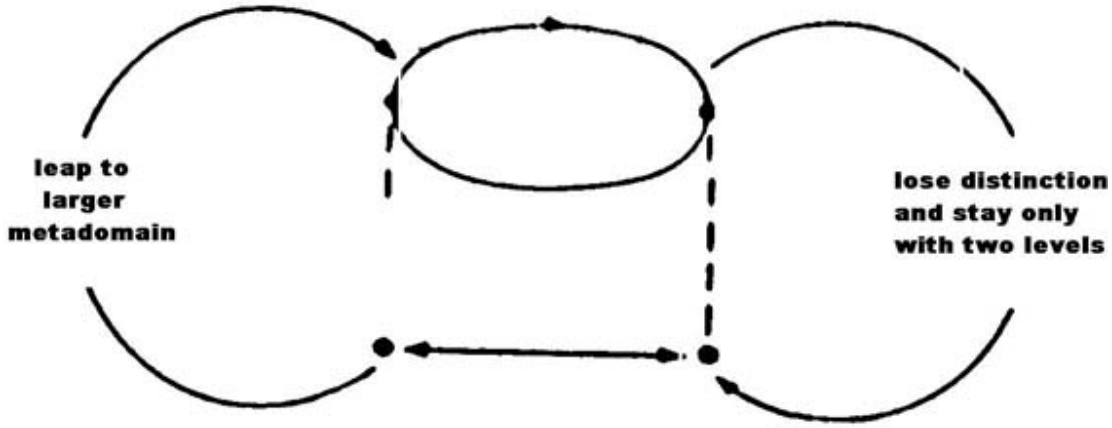


Figure 24

(I suppose this is why paradox appears over and over again in situations such as Zen training, where the learning is precisely that of leaping out to a larger domain where one can consider one's thoughts and values with detachment. To the extent that the student is fixed on one level or another, with one preference or judgment - good or bad, positive or negative, spiritual or mundane - the aim of the teaching is not achieved. A good teacher, I suppose, is one who can convey the unity or circularity, the tangledness of the situation, so vividly that the student is forced to leap out of it.)

Perhaps the most interesting and illustrious evidence of the richness of self-reference in language and mathematics is Godel's theorem, which I shall use as an example to trace some further consequences of closure.

The spirit of Godel is (again) well represented in the Escher engraving. He and others of his time were interested in examining whether formal languages could examine themselves, whether the very inside of mathematics could talk to itself. For this purpose we must concentrate on those mathematical languages that can at least refer to and deal with numbers. Now numbers are not mathematical statements; they are mathematical objects that can be referred to in mathematical language adequate to that task. The genius of Godel was to intercross those two levels, numerical language and numbers: a strange

loop. To make the cross, he chose a correspondence between every symbol in the language and a number, in such a way that strings of symbols (thus statements about numbers) could also correspond to a number. The details need not concern us here [9], but this is the general gist of the language thus constructed by Godel.

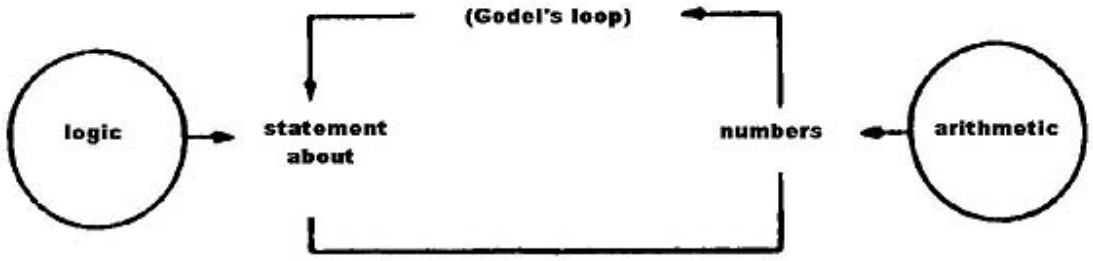


Figure 25

Once this intercrossing of domains is firmly established, it is easy to generate circular sentences like Quine's. In Godel's case it takes the form, "This sentence has no proof" (it cannot be proved either true or false). Now the very existence of such a statement shows that all formal systems rich enough to contain numbers and arithmetic have perfectly well-defined and sensical things that cannot be decided right or wrong; thus, it is said, they are *incomplete*.

That undecidable statements could be thus produced at the very heart of such a central portion of mathematics sent waves of dissatisfaction among mathematicians. From our point of view, however, it is possible to understand Godel's result rather differently: Not one of limitation, but as yet another instance of how closure can lead to the constitution of an autonomous domain, where out of a background a unity emerges and specifies a larger domain. In Godel's case, once the loop is completed and the levels entangled, we have the emergence of a unity in the linguistic universe. The comparison with the biological case is evident:

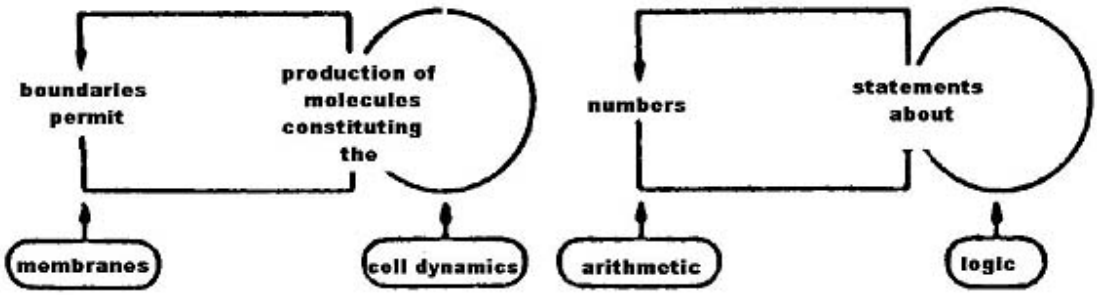
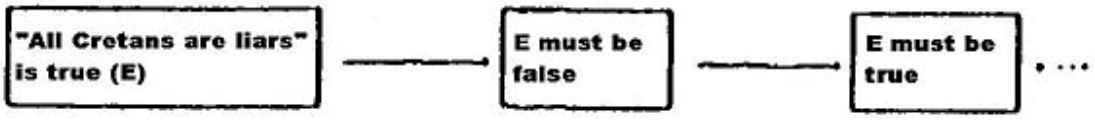


Figure 26

Let us consider for a moment the *inside* of any of these strange loops. In the Epimenides case, if we assume the statement is true, then it is consequently false, then it must be true. Its fine structure is one where there is an oscillation between parts that were previously

separate. We can write it thus:



Or, in the cellular case, we can unfold the circle and obtain also an infinitely growing pattern:

In a unit with operational closure, what appears as *coherent* or *distinguishable* behavior (whether in the domain of meaning or in the domain of molecular structures) has a peculiar nature indeed. On the one hand, it appears as a single property of the unit itself; on the other hand, when we attempt to examine the origin of such a property through its own properties, we find that there is nothing but an indefinite iteration of the same; it starts nowhere and it ends nowhere. The coherence is *distributed* through an ever repeating circle that is infinite in its circulation, yet finite, since we can see its effect or results as a unit's property.

Let me give a more tangible illustration of this same idea. Consider a triangle. Break each side of it in three so as to produce a six-pointed star. Take each side of the star and break these in the same fashion. Repeat the process with every new side, *ad infinitum*. The resulting figure, somewhat like a snow crystal, is immediately graspable; it has coherence as a shape. Yet what we perceive is like a mythical ancestor that can never be fully drawn or described, but only stated as a trend of uninterrupted iteration. Interestingly enough, because of this self-referential geometrical construction, figures such as this have dimensions that are in between the traditional ones (besides having other peculiar properties). In the case of the triangle, the dimension of the final product is greater than 1, but less than 2 - it is exactly 1.2618. Because of their fractional dimension, such figures are called *fractals* (Figure 27) [5].

In the example of a fractal we have all the ingredients, in a visual form, to see how closure in a process can lead (1) to a coherence that is always distributed and thus never fully present, but graspable as a "mythical ancestor" and (2) to properties which are emergent, and not simply added from the component elements that participate in the process.

Figure 27

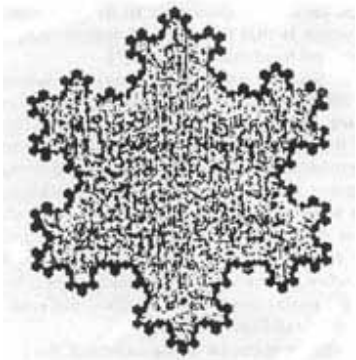


Figure 28

THE COGNITIVE PERPSECTIVE

We have been discussing two instances - whether they be cells and the living, or formal systems and undecidability - where operational closure generates a whole new domain in the apparently harmless act of curling onto itself. At this point, we must take the next step in our examination of the natural history of circularity and explore the next fundamental case where closure changes the picture completely: our own descriptions, our *own* cognizing.

In fact, in considering our own cognizing, we put *together* the essentials of the two previous instances discussed. On the one hand, our cognition is in our biological substrate as body; on the other hand, our descriptions are fully capable of self-descriptions at indefinitely many levels. Through the nervous system, these two modes of closure are superimposed so as to constitute that closest and most elusive of all experiences: ourselves.

It is apparent that the nervous system is a part of our unity as biological beings, an autonomous unit in its own right. What is not so apparent is that the nervous system *itself* is curled on itself in several fundamental ways [7].

First, there is no effect or action of the nervous system (motility, glandular secretion) that does not have a direct effect on a sensorial surface. Just as a neuron acts on another by a close apposition of their surfaces in a synapse, a set of muscles acts on the sensorium of the body through recurrent action or sensorimotor synapse. A knee jerk is produced because a tendon is stretched, proprioceptors are pulled, and the activity of motor neurons in the spinal cord is changed, leading to muscles contracting in the opposite direction of the stretch. Motor actions have sensorial consequences, and sensorial actions have motor consequences. This reafference principle is of universal validity.

But there is still another essential sense in which the nervous system has operational closure. Once we pass the threshold of the sensorium or motorium, the effects of such organs in the nervous system are not like a one-way street or channel where traffic is clearly routed. Rather, it resembles

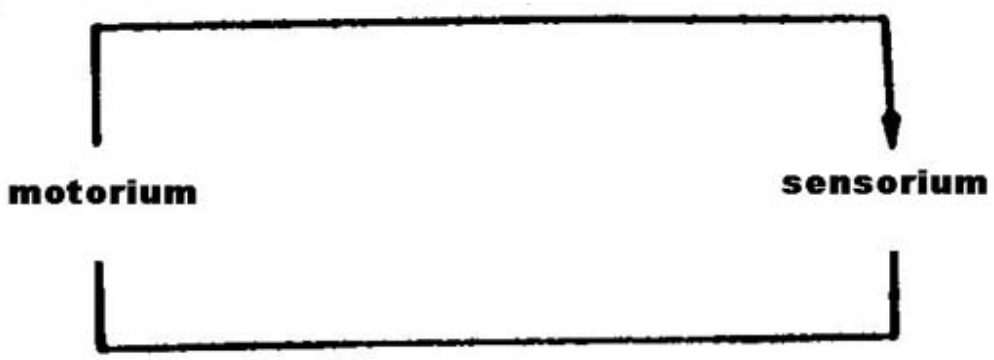


Figure 29

..the addition of one new voice on the floor of the stock market. For example, if we were to travel with the nerve activity originating at the retina into the cortical area (of the occiptal lobe), we would find that for each fiber from the retina entertaining this piece of cortex, 100 other fibers enter at the same spatial location from all over the brain [1]. Thus the activity of the retina at best sculpts or modulates what is going on internally in the high interconnection of the neural layers and nuclei.

But there is still more. Although electrical impulses travel along in only one direction, many other chemicals travel in the opposite direction in the cell's axon, so that routes in the nervous system are always two-way. For example, regulatory metabolites can be taken up at the axon's terminal end, travel toward the cell body, and go across a synapse to act on the preceding neuron with respect to the electrical flow. There are many such mutual effects in the nervous system that are just beginning to be charted [2]. A diagram may help to visualize this organization:

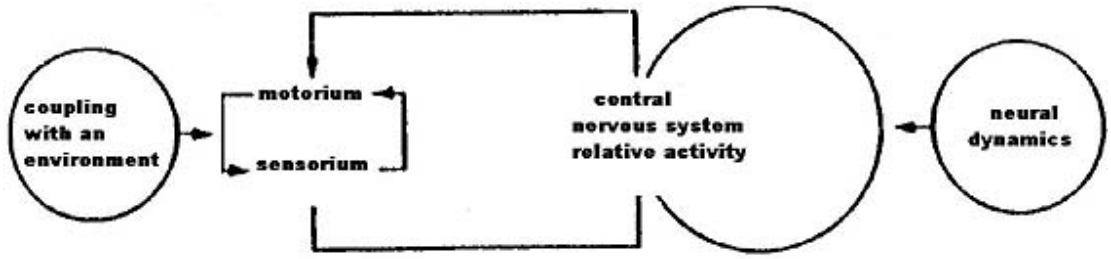


Figure 30

In this view of the nervous system we see a behavior when there is some particular *coherence* attained by the closure of this whole pattern of interconnections. One can analyze this coherence by breaking the process into its parts. We could start, say, with vision as originating in the eye, and then consider all the pathways that lead from the eye into the cortex, and then from the cortex to the thalamus and the forebrain, and so on. Eventually, we would end up in a full circle, and, indeed, we could loop around indefinitely. As in the illustration of a fractal, behavior is like the mythical ancestor of this infinitely recurring process, looping on itself repeatedly.

SUBJECT/OBJECT

If we are thoroughly consistent with what we have said about the nervous system, we must see our own experience arising in the same manner. And if we do so, there are two paramount consequences to consider.

First, that we cannot *step outside* the domain specified by our body and nervous system. There is no world except that experienced though those processes given to us and which makes us what we are. We find ourselves in a cognitive domain, and we cannot leap out of it or choose its beginnings or modes.

Second, and equally important, we cannot trace a given experience to its *origins* in a unique fashion. In fact, whenever we do try and find the source of, say, a perception or an idea, we find ourselves in an ever-receding fractal, and wherever we choose to delve we find it equally full of details and interdependencies. It is always the perception of a perception of a perception…..Or the description of a description of a description....There is nowhere we can drop anchor and say, "This is where this perception started; this is how it was done."

In finding the world as we do, we forget all we did to find it as such, entangled in the strange loop of our actions through our body. Much like the young man in the Escher engraving "Print Gallery", we see a world that turns into the very substratum which produces us, thereby closing the loop and intercrossing domains. As in the Escher engraving, there is nowhere to step *out* into. And if we were to try, we would find ourselves in an endless circle that vanishes into an empty space right in its middle (Figure 31).

Figure 31

Editors note: Escher's biographer Bruno Ernst, explains this print as follows: At the lower right-hand corner we find the entrance to a gallery in which an exhibition of prints is being held. Turning to the left we come across a young man who stands looking at a print on the wall. On this print he can see a ship, and higher up, in other words in the upper left-hand corner, some houses along a quayside. Now if we look along to the right, this row of houses continues, and on the far right our gaze descends, to discover a corner house at the base of which is the entrance to a picture gallery in which an exhibition of prints is being held...So our young man is standing inside the same print as the one he is looking at [The Magic Mirror of M.C. Escher, Random House, New York, 1976, p.31]

Tradition (1) would have it that experience is either a subjective or an objective affair, that the world is there and that we either see it as it is or we see it through our own subjectivity. However, when we follow the guiding thread of circularity and its natural history, we may look at that quandary from a different perspective: that of *participation* and *interpretation*, where the subject and the object are inseparably meshed. This interdependence is revealed to the extent that nowhere can I start with a pure account of either one, and wherever I choose to start is like a fractal that only reflects back precisely what I do: to describe it. By this logic, we stand in relation to the world as in a mirror that does not tell us how the world is: neither does it tell us how it is not. It reveals that it is possible to be the way we are being, and to act the way we have acted. It reveals that our experience is *viable*.

That the world should have this plastic texture, neither subjective nor objective, not one and separable, neither two are inseparable, is fascinating. It points both to the *nature* of the process, which we can chart in all of its formality and materiality, as well as to the fundamental *limits* about what we can understand about ourselves and the world. It shows that reality is not just constructed at our whim, for that would be to assume that there is a starting point we can choose from inside first. It also shows that reality cannot be understood as given and that we are to perceive it and pick it up, as a recipient, for that

would also be to assume a starting point: outside first. It shows, indeed, the fundamental *groundlessness* of our experience, where we are given regularities and interpretations born out of our common history as biological beings and social entities. Within those consensual domains of common history we live in an apparently endless metamorphosis of interpretations following interpretations [12].

It reveals to us a world where "no-ground", "no-foundation" can become the basis for understanding that the age-old idea of objectivity and communication as progressive elimination of error for gradual attunement is, by its own scientific standards, a chimera.

We should do better to fully accept the notoriously different and more difficult situation of existing in a world where no one in particular can have a claim to better understanding in a universal sense. This is indeed interesting: that the empirical world of the living and the logic of self-reference, that the whole of the natural history of circularity should tell us that ethics - tolerance and pluralism, detachment from our own perceptions and values to allow for those of others - is the very foundation of knowledge, and also its final point. At this point, actions are clearer than words.

(1) One should qualify the various alternative traditions that are dissident. A very important one in this regard is phenomenology, and many of its side branches, but we speak here of the dominant common sense.

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